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DIODE STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX 1N5550

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Prepared
for

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

DCA RELIABILITY LABORATORY
SPECIAL PRODUCTS DIVISION
975 BENICIA AVE
SUNNYVALE, CALIFORNIA 94086





FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS was to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.



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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the switching diode JANTX1N5550 manufactured by Semtech and Micro Semiconductor.

1.1 Sample Distribution

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 at each measurement point after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for this device. At least one of the



devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of maximum rated power for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours with temperature steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in the sample lot failed.* Electrical measurements were performed on

*Conditions for failure:

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times
- C) Other parameters exceed MIL limits by 50% or more



all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Semtech and Micro Semiconductor. All Group I - Power Stress Testing was stopped 500 hours into the 50% MRP step because more than 50% of the devices in the Semtech sample lot failed. It is unusual to have a failure rate exceeding 50% of a sample lot, therefore, a preliminary failure analysis was performed on the Semtech sample lot. That failure analysis is included as Appendix A of this report.

3.2 Group II - Temperature Stress I

3.2.1 Semtech. The Semtech sample lot completed 160 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The failures occurred 160 hours into the 75°C-temperature step. Serial numbers 6613, 6614, 6615, 6616, 6619, 6693, 6694, 6695, 6696, 6697, 6698, and 6699 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 5.085mA from an initial mean of 37.51nA to a final mean of 5.085A.
- 2) The mean value for V_{F1} changed 0.01V from an initial mean of 1.041V to a final mean of 1.051V.
- 3) The mean value for V_{F2} changed 1.2mV from an initial mean of 854.4mV to a final mean of 855.6mV.



The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 1600-hour Group II Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed $1.298\mu A$ from an initial mean of $5.03nA$ to a final mean of $1.303\mu A$.
- 2) The mean value for V_{F1} changed $13.3mV$ from an initial mean of $942.1mV$ to a final mean of $955.4mV$.
- 3) The mean value for V_{F2} changed $1.8mV$ from an initial mean of $857.1mV$ to a final mean of $858.9mV$.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II

Table 5 outlines the results of Group II - Temperature Stress I Testing for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Semtech. The Semtech sample lot completed a total of 32 hours of Group III Testing before the lot was stopped because more than 50% of the devices failed. The failures occurred 16 hours into the $150^{\circ}C$ -temperature step but continued processing through the $175^{\circ}C$ -temperature step. Serial numbers 6620, 6621, 6627, 6700, 6701, 6702, 6703, 6704, 6705, 6706, and 6707 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:



- 1) The mean value for I_R changed 2.861mA from an initial mean of 27.90nA to a final mean of 2.861mA.
- 2) The mean value for V_{F1} changed 0.001V from an initial mean of 1.073V to a final mean of 1.074V.
- 3) The mean value for V_{F2} changed 6.0mV from an initial mean of 872.9mV to a final mean of 866.9mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 112-hour Group III Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 53.60nA from an initial mean of 14.52nA to a final mean of 68.12nA.
- 2) The mean value for V_{F1} changed 0.005V from an initial mean of 0.976V to a final mean of 0.981V.
- 3) The mean value for V_{F2} changed 4.8mV from an initial mean of 876.4mV to a final mean of 871.6mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III

Table 6 outlines the results of Group III - Temperature Stress II Testing for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5



plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperature T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups, where applicable. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

An apparent problem arose in the testing of the Semtech devices. The failure rate of the Semtech devices exceeded 50% in all three stress tests at the first sequence point.

A failure analysis done for the Power Stress Group I suggests the possibility of a manufacturing problem. One device studied revealed that its failure was directly attributed to a crack in the die, assumed to be caused from a poor die attach during assembly and subsequent operation. Another device was cross-sectioned at two different angles and no visible anomalies were noted. The failure modes could not be precisely determined although unseen microcracks across the junction were the suspected cause.

In both of the temperature stress tests, the Semtech devices exhibited leakage because of conductive external paint which bridged between the anode and cathode leads, and because of hygroscopic glass (which is protected from moisture as long as the paint is undamaged).

Arcing was clearly visible in the paint when one device was placed under reverse bias of several hundred volts.

The paint of one device was chemically removed, after which the leakage could be varied at will over a large



range by changing the device ambient atmosphere. A dry gas stream played over the diode at room temperature produced low leakage. Free air produced instability and high leakage. A one-minute HF etch was used to remove any possible invisible conductive residue of the paint. After this treatment the glass was still hygroscopic.

A complete plot and activation energy could not be calculated for the Semtech sample lot due to an insufficient number of failure points (Figures 2 and 3). A plot and activation energy could not be calculated for the Micro Semiconductor sample lot due to an absence of failures in the Group II and III Testings.

A solid circle around a marked point on the graph indicates an isolated failure point.

The activation energy was calculated from the formula:

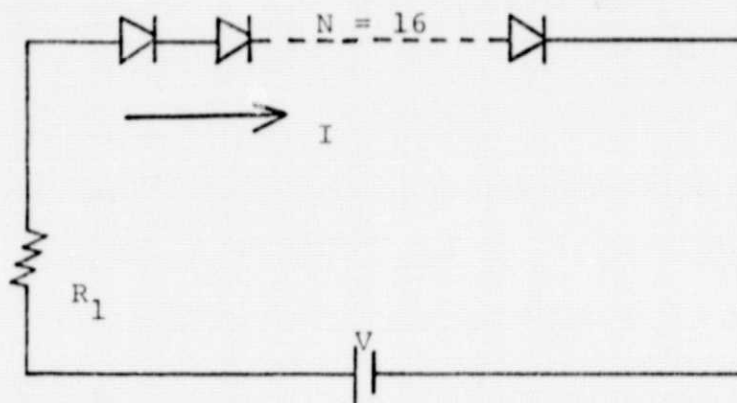
$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^\circ\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.
 t_2 = step of Group III - Temp Stress II = 16 hrs.
 T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.
 T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.



JANTX1N5550

SWITCHING DIODES



$$R_1 = 1V/I \pm 1\%$$

$$P_d = I$$

FIGURE 1
Power and Temperature Stress Circuit



JANTX1N5550

SEMTECH

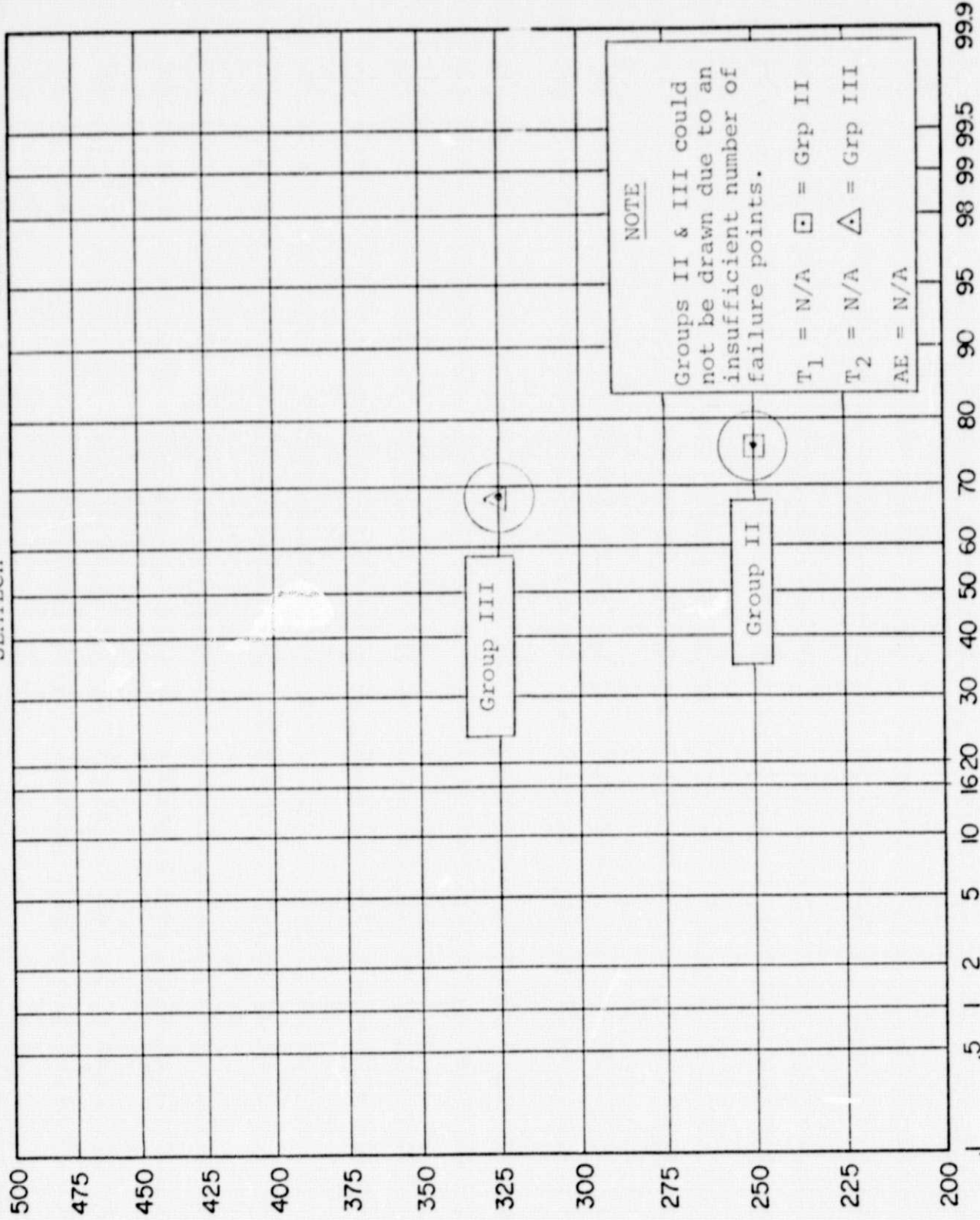
JANTX1N5550

* JUNCTION TEMPERATURE (°C)

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*NOTE

$T_J \approx T_A + 175^\circ\text{C}$



NOTE

Groups II & III could not be drawn due to an insufficient number of failure points.

$T_1 = N/A$ $\square = \text{Grp II}$

$T_2 = N/A$ $\triangle = \text{Grp III}$

$AE = N/A$

CUMULATIVE PERCENT FAILURES (%)

FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Semtech

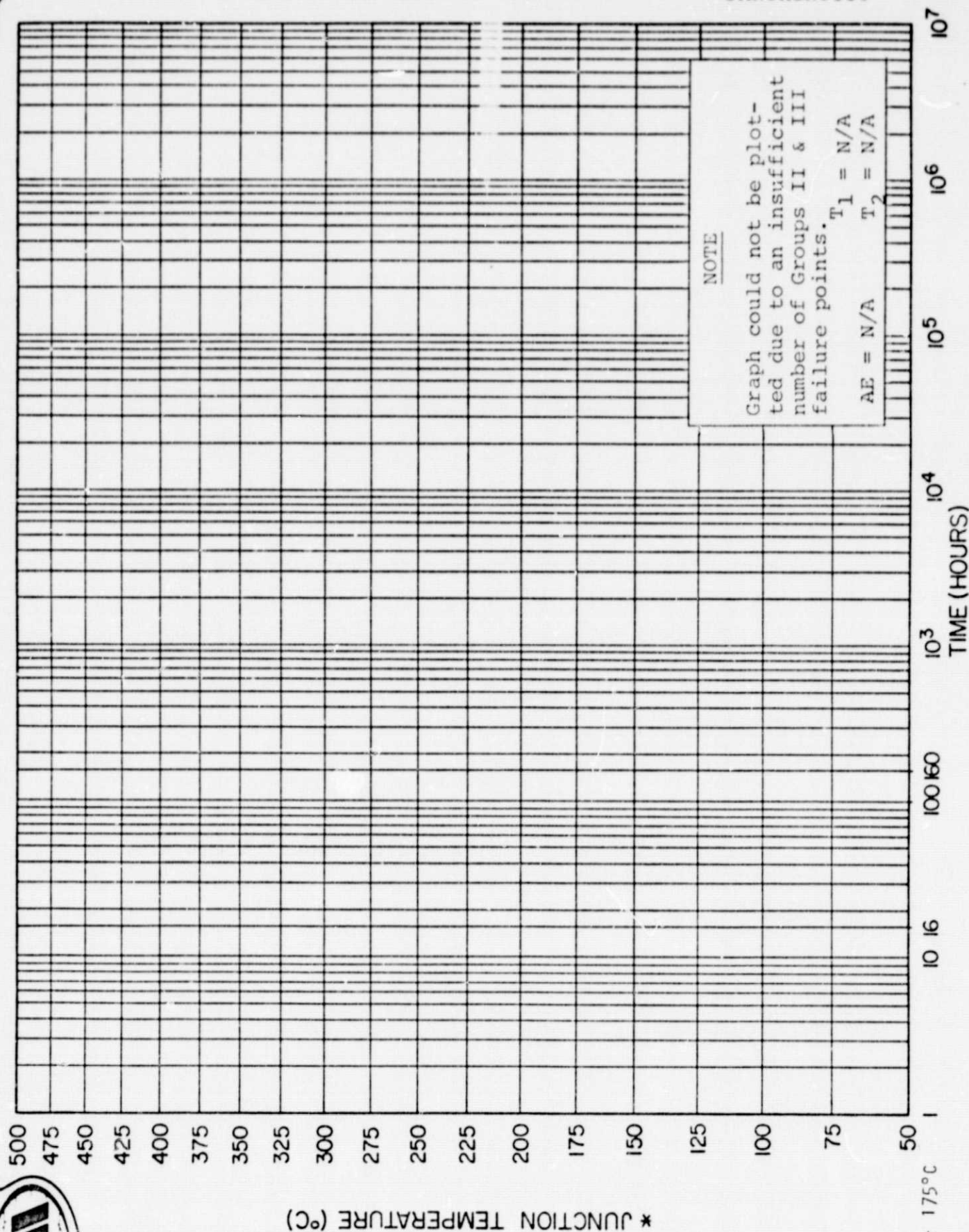


FIGURE 3
 Time Steps Versus Junction Temperature, Semtech





MICRO SEMICONDUCTOR

JANTX1N5550

JANTX1N5550

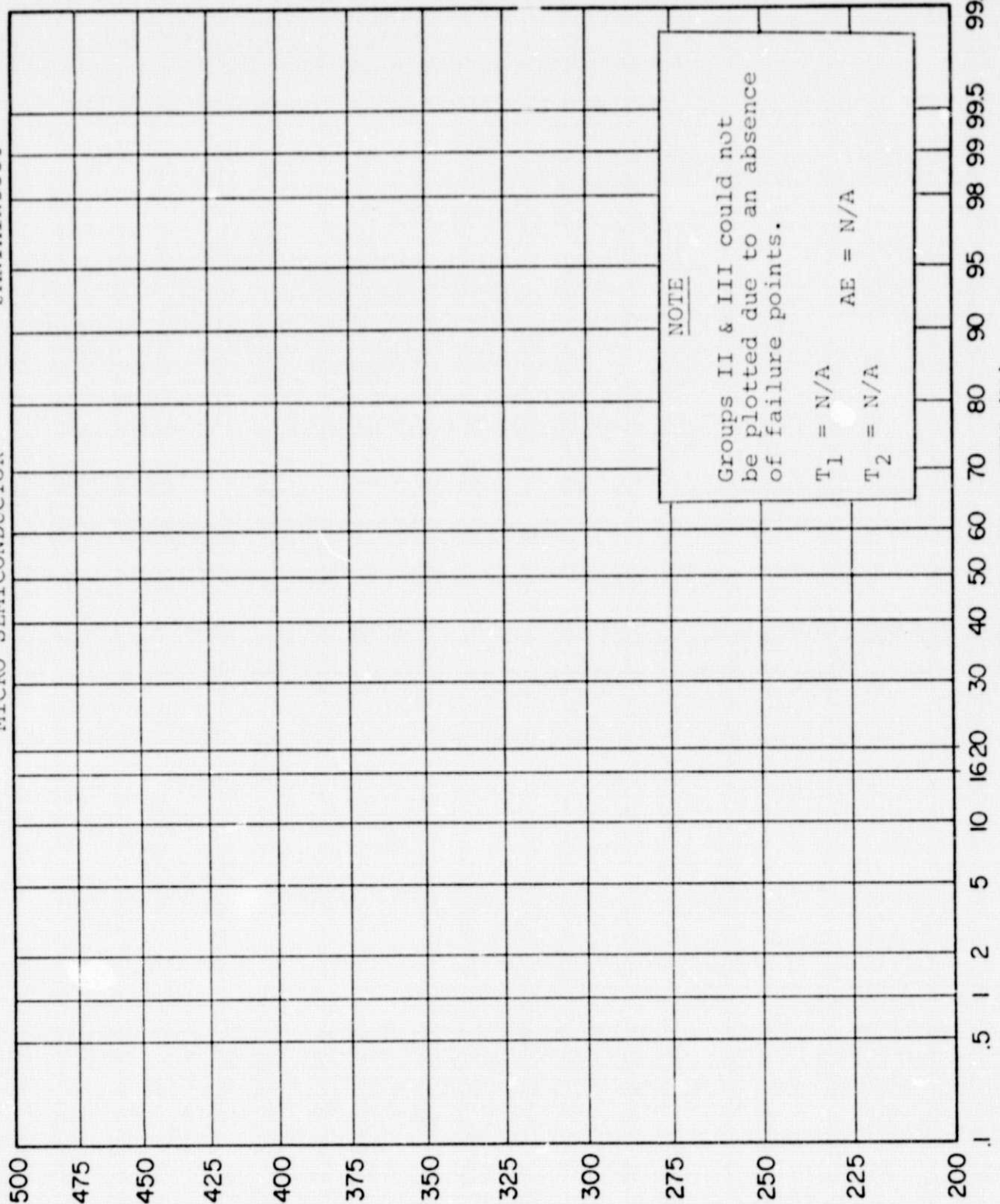


FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor

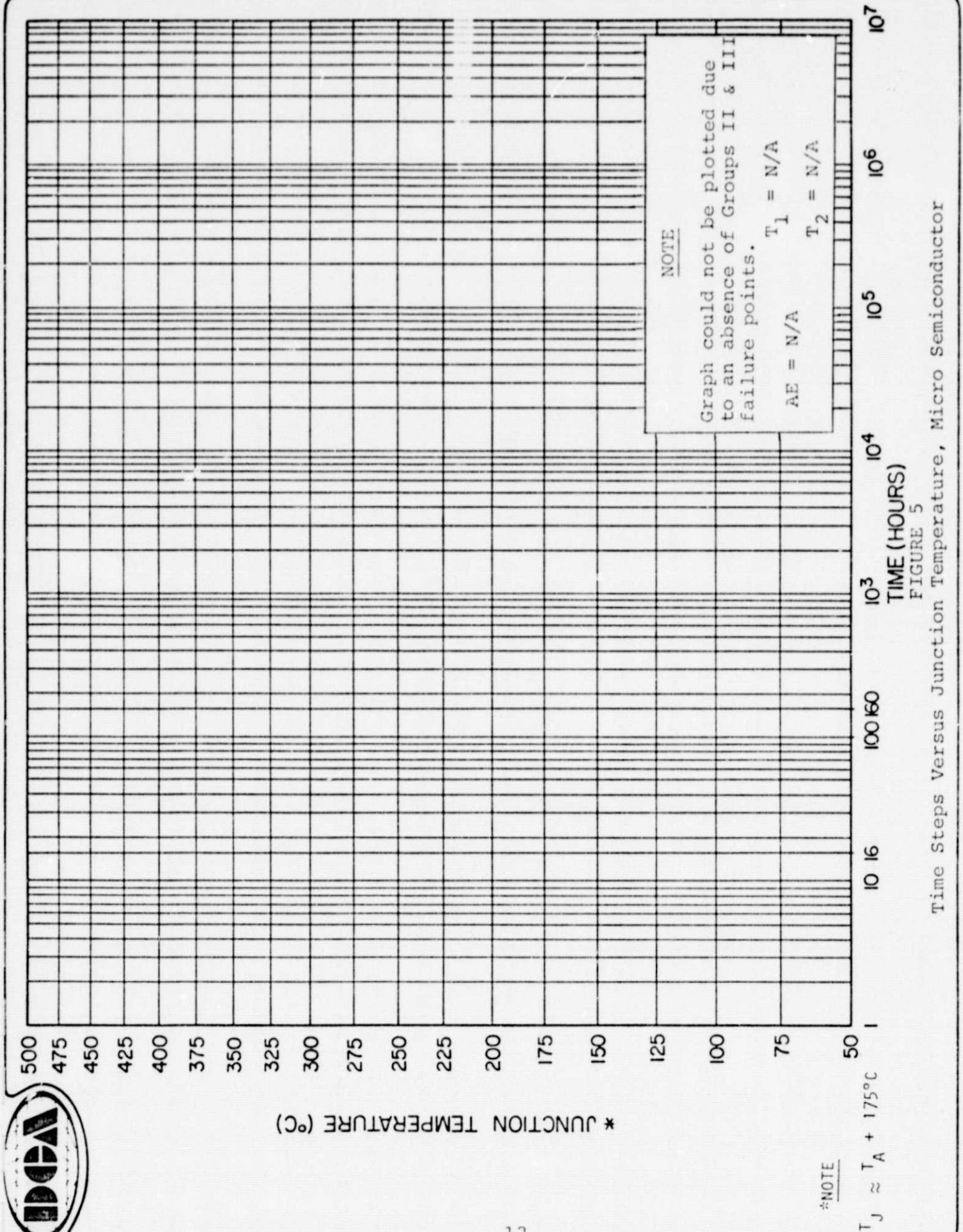
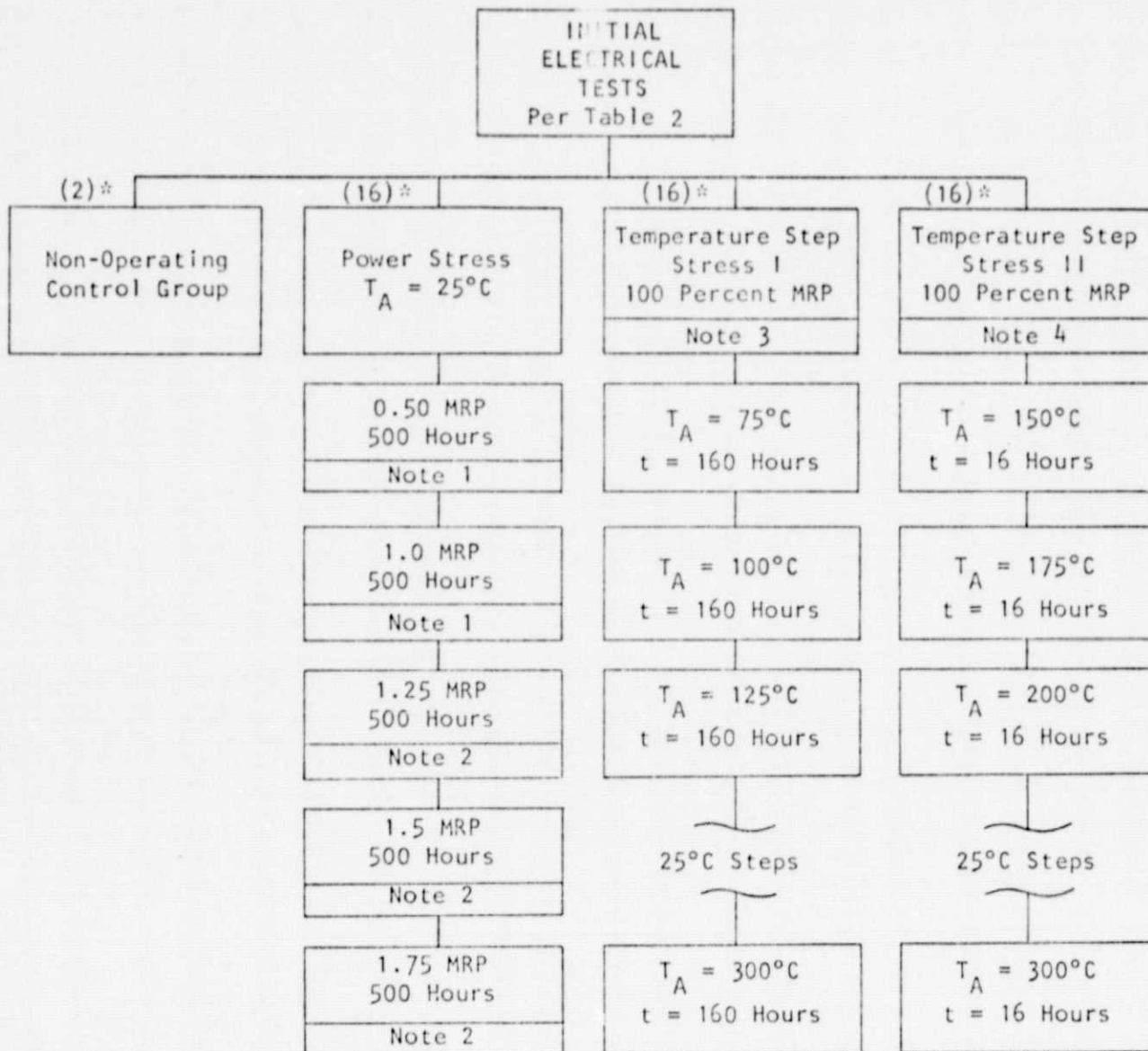


TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (SEMTECH & MICROSEMICONDUCTOR)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



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JANTX1N5550

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC LIMITS		CAT. LIMITS		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ $V_R = 200V$		1.0		100	μA
V_{F1}	@ $I_F = 9.0A (PK)$ PULSED	.6	1.2	.3	1.8	V
V_{F2}	@ $I_O = 2.0A$ (NOT PULSED)	.6	1.2	.3	1.8	V
NOTES:						

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_F = 1.0V$	
$I_F =$	% P_D
240mA	50
480mA	100
600mA	125
720mA	150
840mA	175

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NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

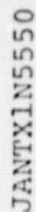


TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

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TABLE 5
GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	$I_F = 1.0 \mu A$ (MAX) @ $V_R = 200V$		$V_{F1} = .6V$ (MIN) 1.2V (MAX) @ $I_F = 9.0A$ (PULSED)		$V_{F2} = .6V$ (MIN) 1.2V (MAX) @ $I_0 = 2.0A$ (NOT PULSED)	
CONDITIONS AND LIMITS	SEMTECH	MSC	SEMTECH	MSC	SEMTECH	MSC
IDENTIFICATION						
INITIAL DATA						
MIN VALUE	20.20nA	2.87nA	0.917V	927.0mV	812.0mA	851.0mA
MAX VALUE	85.50nA	8.65nA	1.160V	979.0mV	895.0mV	865.0mV
MEAN	37.51nA	5.03nA	1.041V	942.1mV	854.4mV	857.1mV
STD DEV	16.72nA	1.64nA	0.075V	13.7mV	26.9mV	856.0mV
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hours						
Temp.						
160	*5.085mA	1.442 μA	0.01V	9.3mV	1.2mV	-0.3mV
320	Job Stopped	1.362 μA	Job Stopped	10.8mV	Job Stopped	0.3mV
480		1.132 μA		12.3mV		0.8mV
640		9.030nA		11.6mV		0.7mV
800		200.570nA		169.9mV		65.0mV
960		5.494 μA		9.8mV		3.2mV
1120		623.770nA		11.1mV		4.9mV
1280		813.870nA		10.3mV		0.9mV
1440		1.060 μA		9.6mV		0.0mV
1600		1.298 μA		13.3mV		1.8mV
FINAL DATA						
FINAL TEMP	75°C	300°C	75°C	300°C	75°C	300°C
MIN VALUE	39.20nA	37.60nA	0.934mV	940.0mV	811.0mV	854.0mV
MAX VALUE	9.99mA	6.450 μA	1.160V	995.0mV	893.0mV	867.0mV
MEAN	5.085mA	1.303 μA	1.051V	955.4mV	855.6mV	858.9mV
STD DEV	4.258mA	1.650 μA	0.075V	13.8mV	26.9mV	3.3mV

* NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6
GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	$I_P = 1.0 \mu A$ (MAX)		$V_{F1} = .6V$ (MIN) 1.2V (MAX)		$V_{F2} = .6V$ (MIN) 1.2V (MAX)	
CONDITIONS AND LIMITS	@ $V_R = 200V$		@ $I_F = 9.0A$ (PULSED)		@ $I_0 = 2.0A$ (NOT PULSED)	
IDENTIFICATION	SEMTECH	MSC	SEMTECH	MSC	SEMTECH	MSC
INITIAL DATA						
MIN VALUE	14.20nA	6.06nA	0.999V	0.957V	846.0mV	869.0mV
MAX VALUE	57.70nA	32.80nA	1.160V	1.070V	913.0mV	904.0mV
MEAN	27.90nA	14.52nA	1.073V	0.976V	872.9mV	876.4mV
STD DEV	11.24nA	5.95nA	0.046V	0.027V	18.1mV	8.2mV
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hours						
Temp						
16	150°C	53.60nA	-0.003V	-0.008V	-9.9mV	-13.6mV
32	175°C	2.861mA	0.001V	-0.011V	-6.0mV	-10.0mV
48	200°C	Job Stopped	Job Stopped	-0.013V	Job Stopped	-13.8mV
64	225°C	193.08nA	193.08nA	-0.009V	-6.8mV	-6.8mV
80	250°C	128.28nA	128.28nA	-0.009V	-14.3mV	-14.3mV
96	275°C	9.48nA	9.48nA	-0.004V	-6.1mV	-6.1mV
112	300°C	198.88nA	198.88nA	0.005V	-4.8mV	-4.8mV
FINAL DATA						
FINAL TEMP	175°C	300°C	175°C	300°C	175°C	300°C
MIN VALUE	0.277μA	23.20nA	0.999V	0.959V	840.0mV	864.0mV
MAX VALUE	9.990mA	1.700μA	1.170V	1.100V	908.0mV	905.0mV
MEAN	2.861mA	213.4nA	1.074V	0.981V	866.9mV	871.6mV
STD DEV	3.292mA	392.5nA	0.052V	0.033V	19.5mV	9.5mV

* NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA



JANTXIN5550

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE								
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II				
	SEMTECH	MSC									SEMTECH	MSC	SEMTECH
	MIN	MAX			SEMTECH	MSC	SEMTECH	MSC	SEMTECH	MSC			
I _R		1.0	μA			*	+5085.0	*	1.3435	*	+2154.5		+0.09263
V _{F1}	.3	1.2	V				+0.010		+0.0268		-0.0010		-0.0070
V _{F2}	.3	1.2	V				+0.0012		+0.00773		-0.00795		-0.00991

* NOTE: Catastrophic reject(s) removed from data.



JAN TX1N5550

FAILURE SUMMARY

TABLE 8 STEP STRESS CATASTROPHIC

GROUP I POWER STRESS

GROUP II 160 HR. TEMP. STEPS

GROUP III 16 HR. TEMP. STEPS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.				
100% 100 hr.				
100 hr.				
250 hr.				
100% 50 hr.				
100 hr.				
100 hr.				
250 hr.				
125% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				
150% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

TEST STEP A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	12	A	0	-
100°C	Job Stopped		0	-
125°C			0	-
150°C			0	-
175°C			0	-
200°C			0	-
225°C			0	-
250°C			0	-
275°C			0	-
300°C			0	-

TEST STEP A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	11	A	0	-
175°C	0	-	0	-
200°C	Job Stopped		0	-
225°C			0	-
250°C			0	-
275°C			0	-
300°C			0	-

MFR "A" = SEMTECH

MFR "B" = MICRO SEMICONDUCTOR

NOTES:

(A) $I_R > 100\mu A$



JAN TXIN5550

FAILURE SUMMARY

PARAMETRIC

TABLE 9 STEP STRESS

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.				
100 hr.				
100 hr.				
250 hr.				
100% 50 hr.				
100 hr.				
100 hr.				
250 hr.				
125% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				
150% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	1	A
100°C	Job Stopped		0	-
125°C			0	-
150°C			0	-
175°C			0	-
200°C			0	-
225°C			2	A
250°C			1	A
275°C			1	A
300°C			7	A

GROUP III 16 HR. TEMP. STEPS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	3	A	0	-
175°C	0	-	0	-
200°C	Job Stopped		0	-
225°C			0	-
250°C			0	-
275°C			0	-
300°C			1	A

MFR "A" = SEMTECH

MFR "B" = MICRO SEMICONDUCTOR

NOTES:

(A) I_R Maximum limit failure



APPENDIX A

PRELIMINARY FAILURE ANALYSIS

Power Stress

Semtech



FAILURE ANALYSIS REPORT

Job Number: 2CN 242-21A
Customer: MSFC Step Stress Program
Part Type: Diode, axial leaded
Part Number: 1N5550
Sample Serial #'s: 6605 and 6691

Constructional Analysis

The diode samples are constructed with a silicon die mounted between axial stud contacts, encased in glass.

Failure Analysis Report

The parts were tested in the following sequence:

1. External Visual
2. Hermeticity: MIL-STD-750, Method 1071.1, Cond. H and C (Acceptable)
3. Electrical Test 1: See attached Reliability Data Sheet. The parts failed I_R parameter.
4. Stabilization Bake: 150°C for four hours. Purpose of this test was to determine if the I_R leakage current could be due to ionic contaminants.
5. Electrical Test 2: The parts were retested and data was recorded. (See attached data sheet.)



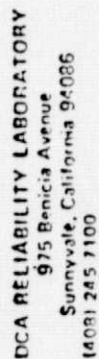
Procedural Failure Analysis Flow

1. No external visual anomalies were noted.
2. Curve tracer analysis (E vs. I curves) showed I_R to be resistive in nature. Bake did not change I_R characteristics, therefore, failure was not due to ionic contaminants.
3. The samples were then sectioned half-way through on the long axis, so as to show both lead attachments and a cross-section of the die.

Internal Visual Inspection revealed die attach voids in greater than 50% area in S/N 6605. The sample also exhibited a longitudinal microcrack in the die (see Figures 2 and 3).

Conclusion

1. S/N 6605 failure is directly attributable to a crack in the die assumed to be caused by stresses created from a poor die attach during assembly and subsequent operation.
2. S/N 6691 was cross-sectioned at two different angles and no visible anomalies were noted. The failure modes could not be precisely determined although unseen microcracks across the junction are the suspected cause.



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RELIABILITY DATA SHEET

Proj. Tech.

ITS 1

Part IN5550

Customer MSFC Step Stress

DCA Job # 2CN 242-21A

[illegible]

Q.C. FORM 101-0-A



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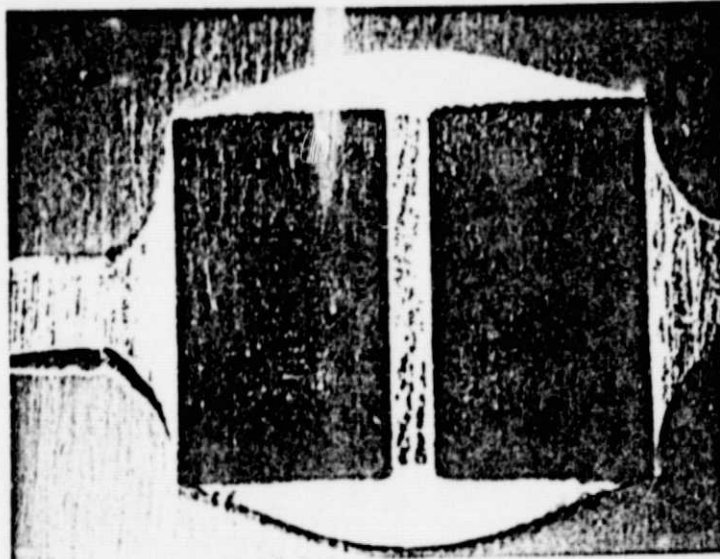


FIGURE A-1
S/N 6605, Semtech.
Overall Cross-sectional View, 19X.
Device not acceptable, see Figures 2 and 3.

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FIGURE A-2
S/N 6605, Semtech.
Magnified View of Die, 19X.
NOTE: Large arrow indicates voids in solder.
Small arrow indicates a microcrack.
Device not acceptable. See Figure 3.



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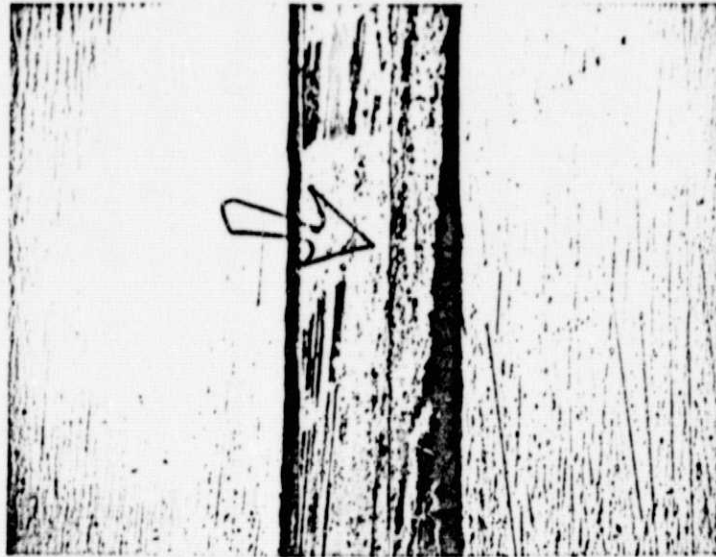


FIGURE A-3
S/N 6605, Semtech, 80X.
Staining has made the microcrack
more prominent. Device not acceptable.

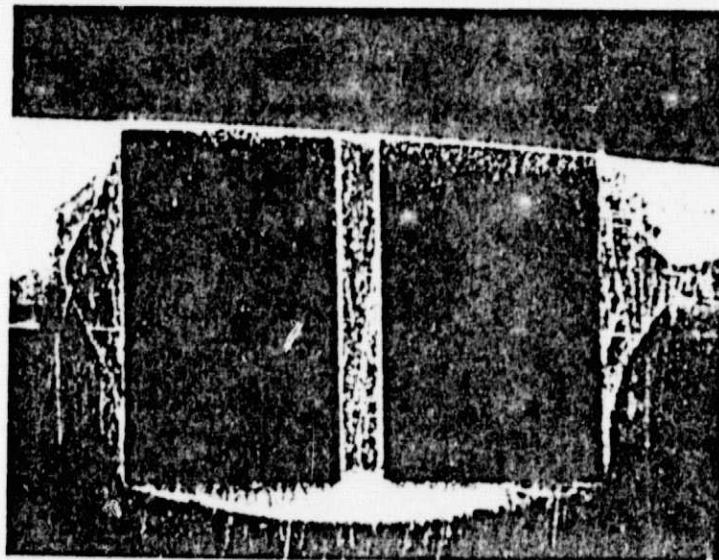


FIGURE A-4
S/N 6691, Semtech, 19X.
Overall Cross-sectional View 0°, accepted device.



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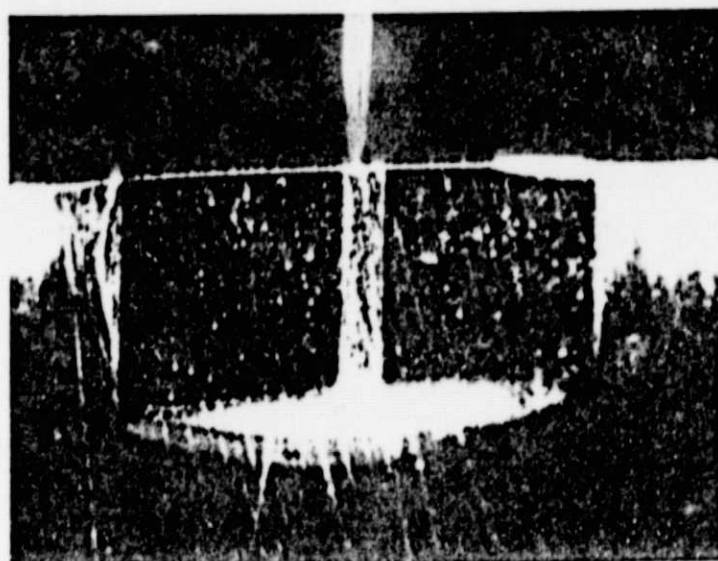


FIGURE A-5
S/N 6691, Semtech, 19X.
Overall Cross-sectional View 90°, accepted device.



APPENDIX B

FAILURE ANALYSIS

Temperature Stress



MSFC STEP-STRESS TEST
FAILURE ANALYSIS

JANTXIN-550

Date 1 May 78

/N 2CN242-21C P/N 1N5550 MFR Semtech

FAILURE VERIFICATION: max= 1.0uA max= 1.2 volts

/N	PIV -volts-	I_r @ 200 V.dc	V_f @ 9.0 A dc	INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
01	1040	2.5mA (R)	1.15	05	I_R
02	1100	3.5mA (R)	1.20	05	I_R
03	1030	2.8mA (R)	1.20	05	I_R

INTERNAL VISUAL INSPECTION

All samples have black paint in various stages of chipping and peeling. No other anomalies are visible.

PAINT CONDUCTIVITY TEST

An ohm meter was used to test the electrical resistivity of the paint remaining on the diodes. Readings were made by pressing the meter probes against the opposite ends of a diode diameter. Results were as follows:

S/N	Resistivity (ohms per diameter)
01	430 k-ohms
02	400 k-ohms
03	460 k-ohms

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* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

MSFC STEP-STRESS TEST
FAILURE ANALYSIS

JANTX1N5550



Date 1 May 78

N 2CN242-21C P/N 1N5550 MFR Micro Semiconductor Co.

FAILURE VERIFICATION: max= 1.0uA max= 1.2 volts

N	PIV -volts-	I _r @ 200 V.dc	V _f @ 9.0 A dc	INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
579	315	1.8uA	1.20	14 (300 ^o , 16 hrs.)	I _R

INTERNAL VISUAL INSPECTION

No visual anomalies were found.

PAINT CONDUCTIVITY TEST

No visible paint remained on the sample. The diode was probed across the glass body with a megohm meter, and no residual conductivity was found.

HERMETICITY (Gross Leakage)

No hermeticity failure was found.

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*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



CONCLUSIONS

The Semtech devices exhibited leakage because of conductive external paint which bridged between the anode and cathode leads, and because of hygroscopic glass (which is protected from moisture as long as the paint is undamaged).

Arcing was clearly visible in the paint when S/N 02 was placed under reverse bias of several hundred volts. S/N 01 and 03 had lost electrical conductivity and continuity in the paint layer.

The paint of S/N 02 was chemically removed, after which the leakage could be varied at will over a large range by changing the device ambient atmosphere. A dry gas stream played over the diode at room temperature produced low leakage. Free air produced instability and high leakage. A one minute HF etch was used to remove any possible invisible conductive residue of the paint. After this treatment the glass was still hygroscopic.

S/N 6679 (Micro Semiconductor)

The slight excess of $0.8\mu\text{A}$ above the acceptable leakage limit is due to contamination within the case. There is no evidence of junction damage in the curve trace.



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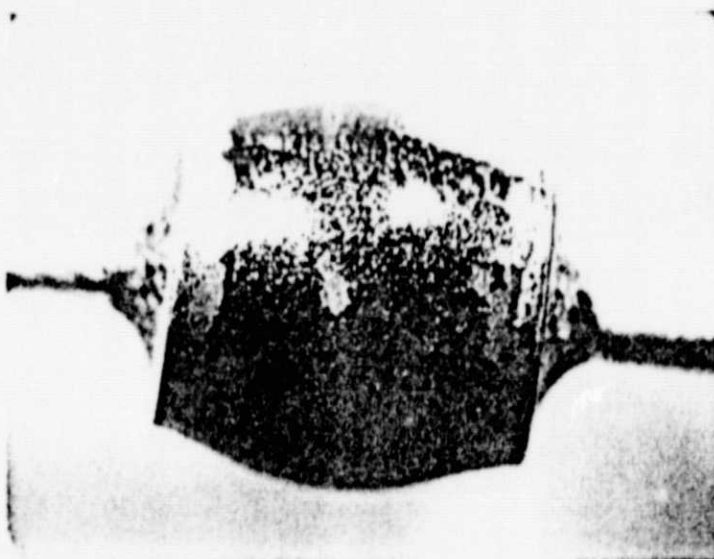


FIGURE B-1
S/N 02, Semtech, 23X.
Overall view of Semtech device showing damaged
paint and accessible metal edges of the leads.

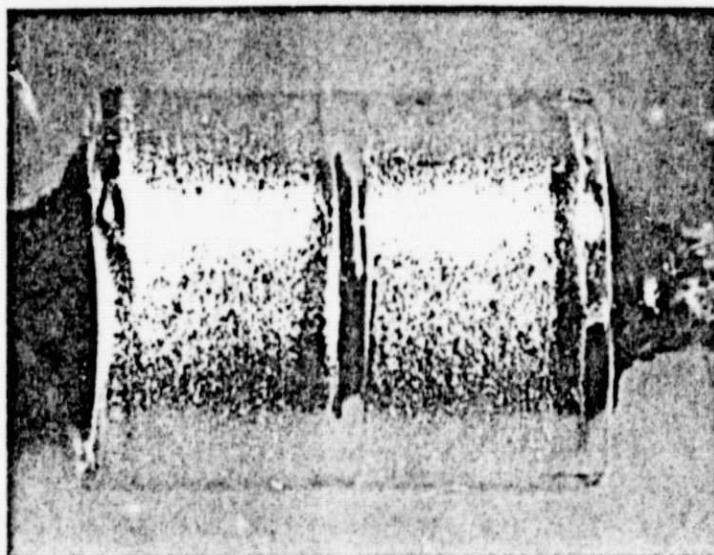


FIGURE B-2
S/N 6679, Micro Semiconductor 16X.
Overall View. No visual anomalies noted.